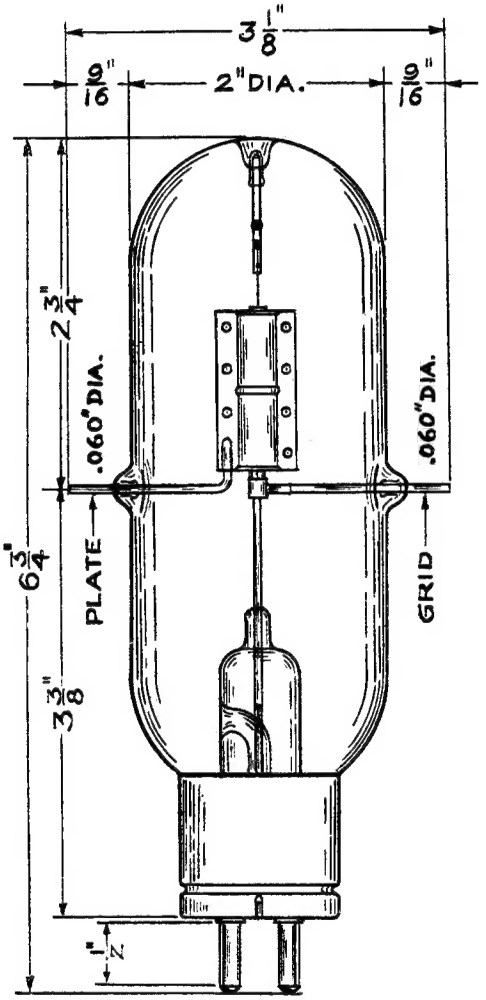
GAMMATRON

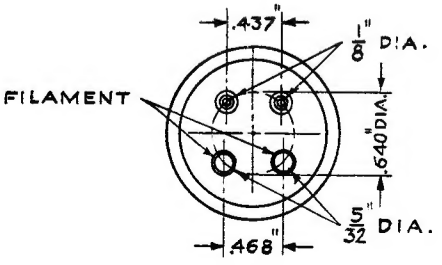
11-36

Engineering Data Sheet
HK-154-1
(Tentative)

GAMMATRON

TYPE HK-154





BOTTOM VIEW OF BASE

PHYSICAL DATA

Plate	Tantalum
Grid	Tantalum
Filament	Thoriated Tungsten
Blank	Nonex Glass
Base	Medium 4 Pin
Base Insulator	Ceramic
Net Weight	3½ Ounces
Shipping Weight	3 Pounds
Maximum Height	6¾ Inches
Maximum Diameter	3⅛ Inches

ELECTRICAL DATA

Filament Voltage	5.0 Volts
Filament Current	6.5 Amps.
Normal Plate Dissipation	50. Watts
Maximum Average Plate Current	175. Ma.
Maximum Plate Voltage	1500. Volts
Maximum Average Grid Current	30. Ma.
Average Plate Impedance	1750. Ohms.
Average Amplification Constant	6.7
Grid-Plate Capacitance	5.9 mmfd.
Grid-Filament Capacitance	4.3 mmfd.
Plate-Filament Capacitance	1.1 mmfd.

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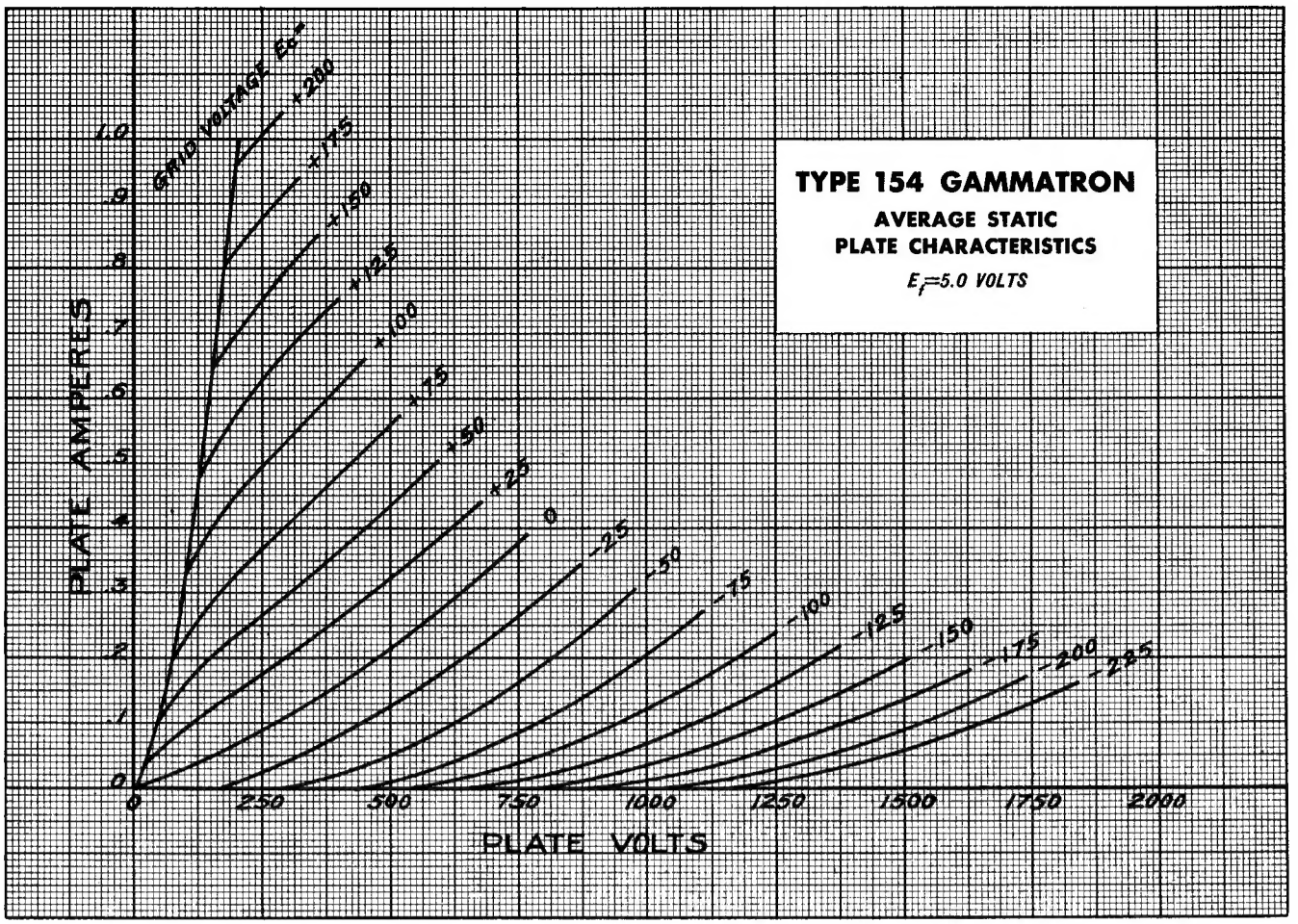
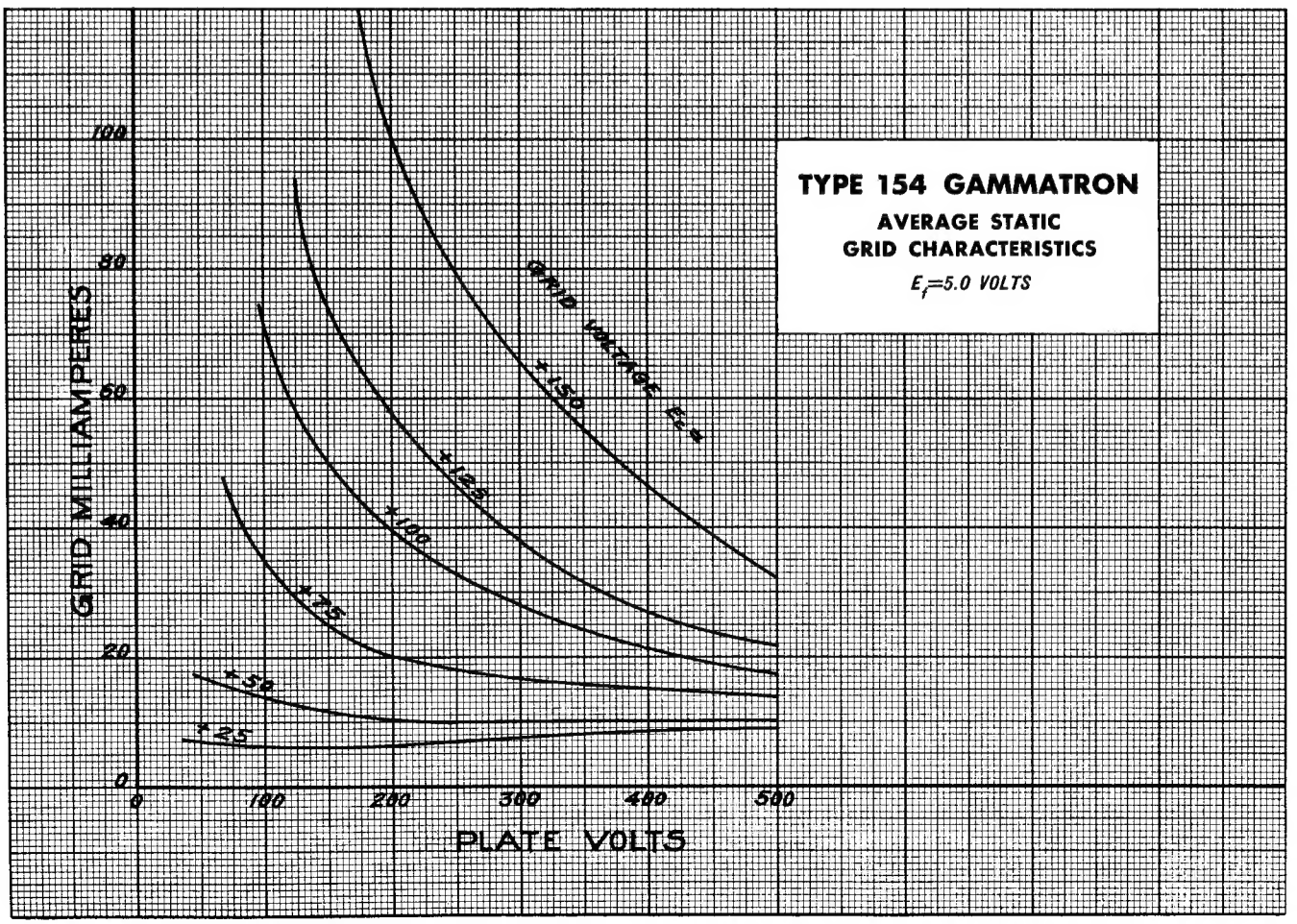

TYPE 154 GAMMATRON
AVERAGE STATIC
PLATE CHARACTERISTICS
E_f=5.0 VOLTS
PLATE AMPERES
PLATE VOLTS
Grid Voltage E_{c1}
+200
+175
+150
+125
+100
+75
+50
+25
0
-25
-50
-75
-100
-125
-150
-175
-200
-225
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
0
250
500
750
1000
1250
1500
1750
2000


TYPE 154 GAMMATRON
AVERAGE STATIC
GRID CHARACTERISTICS
E_f=5.0 VOLTS
GRID MILLIAMPERES
PLATE VOLTS
Grid Voltage E_{c1}
+150
+125
+100
+75
+50
+25
0
20
40
60
80
100
0
100
200
300
400
500

Engineering Data Sheet
HK-154-3
(Tentative)

TYPE HK-154

APPLICATIONS AS A RADIO FREQUENCY AMPLIFIER

Radio Frequency Amplifier—Class "C" (Telegraphy)

The Type HK-154 GAMMATRON is an exceptionally fine radio frequency tube. Used in Class C, surprisingly high outputs are secured at moderately low plate voltages. The tube is remarkably easy to drive. Compare the ratings of other tubes of equivalent size with the "HK-154", which will deliver 200 watts at 1500 plate volts and 125 watts at only 1000 plate volts! And all its ratings apply at 60. megacycles (5 meters) as well!

In the Class C amplifier the tube is biased more negative than necessary for plate current cut-off. The grid is driven positive for a part of each cycle of excitation. This gives a plate current impulse of short duration which develops the output power in the tuned plate circuit. Unusually high plate efficiencies are secured by this means.

Any bias more negative than that required for cut-off gives Class C operation. The reasonably economical bias, however, is that which gives a fairly high plate efficiency with a minimum of driving power. Such a bias is achieved when approximately *twice* the cut-off bias is used. Plate efficiencies of 70-80% can be secured.

This bias may be secured in several ways: namely, from a separate bias rectifier, from a bias battery, by means of a grid leak, or by using extra plate voltage and securing the bias across a resistance from filament to negative terminal of the plate supply. Any of these methods are satisfactory, although one to be recommended highly is that of using a combination of battery bias and grid leak bias. With this last method it would be desirable to use at least 150 volts of negative battery bias, plus the grid leak bias. A D.C. grid current meter should always be used, bypassing it to radio frequency with at least a 0.01 mfd. condenser. The excitation should be adjusted to 20. milliamperes *per tube*. Now, to calculate the correct grid leak subtract the battery bias voltage from the total bias voltage required, then divide the remaining voltage by the *total* grid current in amperes (milliamperes divided by 1000) to determine the correct grid leak (in ohms). Should insufficient driving power be available, decrease the grid leak until the correct grid current of 20 milliamperes per tube flows, being careful that it is not decreased past the value giving 50 watts plate dissipation.

As an indication of plate dissipation let us state that 20 watts just causes the plate to glow, 35 watts gives a dull red, while 50 watts is a medium red.

Neutralizing is extremely important. Complete neutralizing requires that stray coupling be a minimum. Keeping leads as short as possible is the first requisite. Proper location of coils and shields (if used) is necessary. Many times split-stator condensers in conjunction with a symmetrical layout provide the only solution when using two tubes in the Class C stage.

Worthy of particular mention at this point is the "double side-arm" construction of the Type HK-154 GAMMATRON. This aids materially in doing away with long leads, even to the extent of eliminating need of wires running to the tops of the tubes.

When operating the "HK-154" at frequencies greater than 60 megacycles (5 meters) it is advisable to reduce the plate voltage and power. Operation at 250 megacycles (1-1/5 meters) may be attained with 600 plate volts.

Class "C" (Telephony)

The use of the Type HK-154 GAMMATRON in Class C for radio telephone (using plate or high level modulation) is exactly the same as just described for Class C telegraphy except that the plate voltage varies above and below the plate supply value with the audio frequency modulation. Due to the increased values on modulation peaks a maximum of 1250 plate supply volts should not be exceeded. Operating conditions should be determined as explained above for the plate voltage available. In order to attain 100% modulation, audio power equal to one-half the total Class C plate power input should be secured.

R. F. POWER AMPLIFIER—CLASS "C"

TABLE I

(SINGLE TUBE)

Plate Supply Volts	Plate Milli-amperes	Grid Bias Volts	Grid Milli-amperes	Effective Excitation Volts	Driving Power Watts	Power Input Watts	Load Resistance Ohms	Power Output Watts	Plate Loss Watts	Plate Efficiency Per Cent
750	175	–260	20	310	9	131	1920	85	46	65
1000	175	–380	20	420	10	175	2480	127	48	73
1250[1]	170	–460	20	470	12	212	3370	162	50	76
1500[2]	167	–590	20	560	15	250	4180	200	50	80

[1]Maximum rated plate voltage for modulated amplifier.

[2]Maximum rated plate voltage for c.w. telegraph.

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Engineering Data Sheet
HK-154-4
(Tentative)

11-36

RADIO FREQUENCY AMPLIFIER—CLASS "B" (LINEAR)

It is frequently desirable to build a transmitter of moderate power which requires practically no audio frequency power for modulation. The attendant cost of high powered audio equipment for modulation of a Class C amplifier many times imposes this limitation. Class B radio frequency amplification offers the most likely solution.

Should a low-powered radio telephone be available complete with audio system, a stage of one or more Type **HK-154 GAMMATRONS** may be added to its output, using the modulated low-power transmitter as the driver. Carrier output of 25-30 watts power per tube may then be secured, the "HK-154" amplifier satisfactorily handling up to 100% modulation.

The carrier radio frequency power required is low, being of the order of three to five watts, dissipating one-half to two-thirds of the input power in a non-inductive resistor shunting the driving circuit. This insures good regulation from the driver. As with Class C, neutralization is exceedingly important and may frequently be facilitated through the use of two tubes in the Class B radio stage, arranging the tubes in a symmetrical manner with split-stator condensers and all leads as short as possible.

RADIO FREQUENCY AMPLIFIER PERFORMANCE—CLASS "B"

TABLE II CARRIER WITH 100% MODULATION (SINGLE TUBE)

Plate Supply Volts	No-Signal[1] Plate Milliamps.	Plate Current Milliamps.	Grid Bias Volts	Carrier Excitation Peak Volts	Peak Driving[2] Power Watts	Load Resistance Ohms	Carrier Output Watts	Plate Loss Watts	Plate Efficiency Per Cent
750	40	75	−100	108	5	2000	18	48	28
1000	30	75	−155	127	5	3750	25	50	33
1250	25	61	−210	150	5	5700	26	50	34
1500	20	52	−265	175	5	8000	28	50	36

Arithmetic sum of 2nd, 3rd, and 4th harmonics of modulated wave are not greater than 10% at 100% modulation, and under 7% at 75% modulation.

[1]Lower no-signal plate currents will increase distortion.

[2]At crest of audio cycle with 100% modulation.

RADIO FREQUENCY AMPLIFIER—GRID MODULATED

It is frequently desirable to use the **HK-154 GAMMATRON** with grid modulation. The audio system required to effect radio telephone operation is negligible.

The D.C. grid bias for such operation should be of the order of 1.5 to 2.0 times that given in the table above for Class B linear operation. The resultant carrier output is comparable with or slightly less than that in the table. The load resistance is approximately the same.

As with a Class B linear amplifier the driver should have good regulation. This means that seven to ten watts of radio frequency power should be available and the r.f. input circuit loaded with a non-inductive resistor of a value which will absorb one-half to two-thirds of the excitation power. The audio power required is from three to five watts.

Frequently a cathode resistor in combination with fixed bias is used to increase the efficiency and improve the linearity of the grid modulated amplifier. Such methods have been discussed in various radio publications and it is suggested that should the reader be interested further he refer to current publications.

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TYPE HK-154

APPLICATIONS AS AN AUDIO AMPLIFIER

Audio Frequency Amplifier—Class "A"

The Type HK-154 GAMMATRON is an excellent audio power amplifier having an exceedingly low plate resistance and is suitable for comparatively low plate voltage operation. The extremely high mutual conductance insures high power outputs.

Plate dissipation is limited to 50 watts, which in turn makes the tube ideally suited for large public address systems and high quality audio modulator use where class "A" quality is desired. The actual plate dissipation wattage may be judged by the glow of the plate. When judging by glow 20 watts is just visible, 35 watts gives a dull red and 50 watts shows a medium red.

Load resistance is an important factor since its appreciably affects the audio power output and the distortion (quality). Ordinarily it is advisable to use a load of approximately twice the plate resistance of the tube unless limited by plate dissipation. A higher load resistance reduces the distortion but also reduces the power output.

Bias affords a very satisfactory control over the variations which may occur between individual tubes. An adjustment of the bias to obtain the proper plate current (as listed below) at a given voltage will assure correct operation. Where two tubes are used in push-pull individual bias adjustments are sometimes provided to secure complete balancing of plate current.

Plate voltages from 500 to 1250 are recommended for the Type HK-154 GAMMATRONS, higher values being of little benefit. Should difficulty be experienced due to excessively high plate currents at various voltages, the trouble can frequently be traced to oscillation or radio frequency pickup. This is sometimes caused by using a grid leak having considerable inductance.

Driving power with Class A operation is practically nil, maximum output being available when the grid swing goes to zero bias.

TABLE III

CLASS "A" AUDIO AMPLIFIER PERFORMANCE
(SINGLE TUBE)

Plate Supply Volts	Plate Milli-amperes	Grid Bias Volts	Plate Input Watts	Load Resistance Ohms	Power Output Watts	Plate Efficiency Per Cent	Per Cent Second Harmonic
500	60	– 45	30	5,000	3.5	12	6
750	67	– 87	50	6,500	9.0	18	7
1000	50	–137	50	15,000	13.5	27	8
1250	40	–190	50	22,500	15.5	31	7

CLASS "A" AUDIO PUSH-PULL AMPLIFIER PERFORMANCE
(TWO TUBES)

TABLE IV

Plate Supply Volts	Plate Milli-amperes	Grid Bias Volts	Plate Input Watts	Plate-to-Plate Load Ohms	Power Output Watts	Plate Efficiency Per Cent	Per Cent Third Harmonic
500	100	– 50	50	10,000	7	14	3
750	133	– 87	100	10,000	20	20	3
1000	100	–137	100	17,000	35	35	4
1250	80	–190	100	30,000	40	40	4

GAMMATRON

Engineering Data Sheet
HK-154-6
(Tentative)

11-36

AUDIO FREQUENCY AMPLIFIER—CLASS "B" MODULATOR

For high audio output Class B operation is necessary. Outputs of the order of 250 watts of audio frequency power may be secured by using a pair of Type HK-154 GAMMATRONS. In this manner of operation only one tube works at a time, the other tube idling during approximately half of each audio frequency cycle. Power efficiencies are practically doubled with this system. Two tubes are required, however, using a circuit similar to that used with push-pull.

To secure maximum output sufficient bias is used to keep the no-signal plate current quite low, When input signal is applied the plate current increases considerably. This plate current variation requires a plate power supply of very good regulation in order to maintain the voltage constant. Usually mercury vapor types of rectifier tubes and low resistance chokes are used to attain this regulation.

Likewise, the grid current and grid load fluctuate so that ample driving power is needed in order that the tube input circuit changes will not appreciably affect the input audio frequency wave. A low impedance driver should, therefore, be used as this type of driver gives the best regulation. For this reason it is unwise to use tubes connected in any manner except as triodes. (Avoid tetrode and pentode circuits). The Type HK-154 GAMMATRON is truly easy to drive, requiring only 10 watts peak driving power.

Due to the manner in which Class B operates the plate-to-plate output load resistance is *four* times the optimum single plate load resistance. Therefore, the secondary load impedance may be considered as acting on a single tube through one-half the primary.

When operating tubes in Class B audio it is wise to use battery bias if possible. If a separate bias rectifier is provided, make certain that the bleeder current is fairly high so that the grid current variation will not materially affect the bias voltage. Bypass the bleeder resistance with a large (8. mfd. or more) condenser to insure best results. If oscillation is encountered, as indicated by high no-signal plate current, load *each* half of the input transformer secondary with about 50,000 ohms.

The table below gives average operating data, no allowance being made for transformer losses. The driver tubes are mentioned only in the way of a suggestion, many other equivalently rated tubes being satisfactory.

CLASS "B" AUDIO AMPLIFIER PERFORMANCE

TABLE V

(TWO TUBES WITH MAXIMUM SIGNAL APPLIED)

(Total arithmetic sum of 3rd, 5th, 7th, and 9th harmonics will not exceed 10%)

Plate Potential Supply Volts	No-signal[1] Plate Milli-amperes	Grid Bias in Volts	Plate-to-Plate Load Resistance Ohms	Grid-to-Grid Peak Signal Volts	Peak[2] Driving Power Watts	Plate Current Milli-amperes	Power Output in Watts	Plate[3] Loss in Watts	Plate Efficiency in Per Cent
750	80	−100	4,000	430	10	350	150	112	57
1000	60	−155	7,500	510	10	300	200	100	66
1250	50	−210	11,400	600	10	256	223	100	69
1500	40	−265	16,000	700	10	230	250	95	72

[1]Lower no-signal plate currents will cause somewhat higher distortion.
[2]Instantaneous peak power in watts drawn by grid at crest of wave. Effective power is one-half this value.
[3]Plate loss may be slightly greater at lower signal levels.

Driver Transformer Ratio With Suggested Driver

Pair of 2A5 or 42 Tubes

Push-Pull Triode Connection (Screen Tied to Plate)
350 V. on Plate With *Fixed Bias*

Gammatron Plate Voltage	Transformer Turns Ratio
750	1.25:1
1000	1.00:1
1250	0.90:1
1500	0.75:1

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